

## **REMARKS**

### **Comments on Amendments**

Claim 1 has been amended to specify the removal of the carbon dioxide from the gas stream is accomplished in a single absorption stage, and that the ratio of aqueous washing solution to gas is from 1.0 to 10 on a weight/weight (w/w) basis . Support for these amendments is found on page 7 of the specification, lines 14-21 and in the Example on pages 8-9.

Claim 1 has been further amended to recite that as a result of the washing step, a carbon dioxide loaded aqueous washing solution is obtained and a purified gas stream, and that the carbon dioxide loaded aqueous washing solution is substantially free of insoluble carbamates. Support for these amendments is found in the Example on pages 8-9 of the specification, and page 3, lines 7-18, wherein it is disclosed that contrary to the teachings of the prior art, insoluble carbamates are not a problem when sulfolane is used as the physical solvent in the non-dilute aqueous washing solution of the present invention.

Claim 15 has been amended to specify the absorbent liquid contains absorbed carbon dioxide yet is substantially free of insoluble carbamates. Support for the amendments is found on page 3 of the specification, lines 7-18, wherein it is disclosed that contrary to the teachings of the prior art, insoluble carbamates are not a problem when sulfolane is used as the physical solvent in the non-dilute absorbent liquid of the present invention.

New claim 24 recites a preferred aqueous washing solution to gas ratio of between 2 and 6, which ratio is disclosed on page 7 of the specification, lines 20-21.

New claims 25, 26 and 27 specify the amine in the aqueous washing solution or absorbent liquid is DIPA. Support for the new claims is found on page 5 of the specification, lines 21-22.

### **Comments re Patentability of Amended Claims**

The present claims, as amended, are believed to be patentable of Wagner et al (US 4,997,630) in that Wagner et al is directed to a two stage absorption process for the removal of CO<sub>2</sub> and/or H<sub>2</sub>S from gas streams. In the first absorption stage the CO<sub>2</sub> and/or H<sub>2</sub>S containing gas stream is treated at a temperature from 40 °C to 100 ° C with an aqueous alkanolamine-containing absorption liquid containing from 20 to 70 wt% methyldiethanolamine (col.1, lines 21-29). Treated gas from the first absorption stage is fed to the second absorption stage to effect

further removal of CO<sub>2</sub> and/or H<sub>2</sub>S at a temperature from 30 °C to 90 °C using an aqueous alkanolamine-containing absorption liquid also containing from 20 to 70 wt% methyldiethanolamine (MDEA), and having a lower content of CO<sub>2</sub> and/or H<sub>2</sub>S than the absorption liquid fed to the first stage (col. 1, lines 29-36). Wagner et al also teaches that the absorption liquid can advantageously employ from 0.05 to 1 mol/l of piperazine in addition to the methyldiethanolamine (col. 2, lines 35-43).

In marked contrast to the two stage process of Wagner et al, the present claims, as amended, provide that the removal of CO<sub>2</sub> is accomplished in a single absorption stage using an absorption liquid containing specific amounts of amine, sulfolane, water and piperazine, at an aqueous washing liquid (solvent) to gas ratio of 1.0 to 10 (w/w), preferably between 2 and 6. Wagner et al requires two interactive absorption stages and does not teach the solvent to gas ratios recited in amended claims 1 and 24.

Regarding the use of physical solvents, Wagner et al discloses that the absorption liquid containing from 20 to 70 wt% methyldiethanolamine “can additionally contain a physical solvent.” (col. 2, lines 44-46). Wagner et al gives examples of suitable physical solvents which are said to include N-methylpyrrolidone, tetramethylene sulfone, methanol, SEPASOLV SPE and SELEXOL (col. 2, lines 46-51). It is disclosed that if a physical solvent is used it can be employed in amounts of from 1 to 60, preferably from 10 to 50, in particular from 20 to 40 wt% (col. 2, lines 51-54). There is no indication that Wagner et al ever actually used an absorption liquid containing a physical solvent in addition to the 20 to 70 wt% methyldiethanolamine. The absorption liquid employed in the sole Example in Wagner et al was a 50 wt% aqueous methyldiethanolamine solution (col. 6, lines 55-58). It did not contain a physical solvent, nor is there any indication in Wagner et al that a physical solvent is necessary to achieve the objectives of the invention, or that a physical solvent is even desirable. The use of a physical solvent is only mentioned as a possibility, i.e., something that “can” be done. Not something that “should” be done or “must” be done.

It is quite likely that Wagner et al did not actually use an absorption liquid containing a high concentration of physical solvent because an earlier patent (Appl et al, US 4,336,233), which had inventors in common with the Wagner et al (US 4,997,630), teaches that only very dilute solutions of physical solvents can be used together with piperazine because of the formation of piperazine carbamate (Appl et al, col. 3, lines 33-35). Thus, at least some of the

inventors on the Wagner et al patent were aware that high concentrations of physical solvents could result in the precipitation of insoluble piperazine carbamates.

Contrary to the teachings of the prior art Appl et al patent, Applicants have surprisingly found that the problem of insoluble carbamate formation does not occur when a specific physical solvent, sulfolane, is used in certain proportions with water and amines such as MDEA and DIPA, and specific amounts of piperazine. Independent claims 1 and 15 have been amended to recite the aqueous washing solution/absorbent liquid in accordance with the invention is substantially free of insoluble carbamates, despite containing a relatively high concentration of sulfolane (from 15 to 40 parts by weight). This is believed to make the present claims distinguishable from the prior art Appl et al patent which teaches that piperazine carbamate precipitation is a problem when non-dilute solutions containing a physical solvent are employed with piperazine.

New claims 25, 26 and 27 are believed to be distinguishable over Wagner et al in that they specify the amine in the aqueous washing solution/absorbent liquid is DIPA (diisopropanolamine). Wagner et al teaches that the absorbent liquid used in both the first and second absorption stages must contain from 20 to 70 wt% methyldiethanolamine (MDEA). There is no teaching in Wagner et al of using DIPA in the two stage absorption process therein disclosed.

## Summary

Present claim 1 (and the claims that directly or indirectly depend thereon) are patentable over Wagner et al in that Wagner et al teaches a two stage absorption process, while claim 1, as amended, is directed to a single stage absorption process. Also, Wagner et al does not teach the solvent to gas ratios (1.0 to 10 w/w and 2 to 6 w/w) recited in claims 1 and 24, respectively.

Present claim 1 and claim 15, as amended, are patentable over Wagner et al for the additional reason that they exclude the presence of any substantial amounts of insoluble carbamates, which the prior art teaches are formed unless very dilute aqueous solutions of physical solvents are employed. Applicants surprisingly found that the problem of piperazine carbamate precipitation taught in the prior art, does not occur with the present compositions which employ a specific amount of a particular physical solvent, i.e., from 15 to 40 parts by weight sulfolane.

Wagner et al uses an absorbent liquid containing from 20 to 70 wt% methyldiethanolamine in both stages of the disclosed two-stage process. There is no teaching in Wagner et al of an absorption liquid containing DIPA as recited in new claims 25-27.

## **Conclusion**

For the above reasons and in view of the amendments, claims 1-4, 9, 12-16, 20, 23 and new claims 24-27, are believed to be patentable over Wagner et al. Accordingly, reconsideration and favorable action on the application is respectfully requested.

Respectfully submitted,

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